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ABSTRACT

Descriptive data on allocated time, engaged time, and academic learning time are presented and examined. The thesis of this paper is that the marked variability in these three variables is the most potent explanatory variable to account for variability in student achievement, after initial aptitude has been removed as a predictor variable. A corollary of this thesis is that interactive teaching behaviors can only be understood through their effects on academic learning time. (MP)

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Paper presented at the meetings of the National Council on Teaching Mathematics, San Diego, California, April 12, 1978.

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The staff of the Beginning Teacher Evaluation Study proposed to investigate elementary school reading and mathematics instruction in a slightly novel way. They made a simple modification of the process-product approach to the study of classroom learning. The modification is based on the belief that what a teacher does at any one moment in time while working in a circumscribed content area affects a student primarily at only that particular moment in time and in that particular content area. Therefore, the link between teacher behavior and student achievement is the ongoing student behavior in the classroom learning situation. The logic continues in this way. What a teacher does to foster learning in a particular content area becomes important only if a student is engaged with appropriate curriculum content. Appropriate curriculum content is defined as curriculum that is logically related to the criterion and is of an easy level of difficulty for the student. Thus, a second-grade student engaged in the task of two column addition, without regrouping, either by means of a workbook or by watching the teacher at the chalkboard, is engaging in processes that can lead to proficiency in ~~decoding blends~~ two column addition, if the task requires a low error rate on the part of the student. The variable used for research purposes is the accrued engaged time in a particular content area with materials that are of an easy level of difficulty. This complex variable is called Academic Learning Time (ALT). Though probably not linear, the accrual of ALT is expected to be a strong positive correlate of achievement.

Error Rate and ALT

Our original belief was that engagement with curriculum materials of an intermediate level of difficulty would lead to greater achievement. Our data, however, have convinced us that young children trying to learn mathematics in traditional classroom settings need to work on academic tasks that give rise to low error rates for the students. A low error rate occurs when about 20 percent or fewer errors are noted for a student engaged in workbook pages, tests or classroom exercises. When a student's responses are not overt, an observer must estimate the level of difficulty of the activities in which the student is engaged.

Certainly trying to keep a student engaged for too long with too many easy mathematics tasks will not help a student's academic performance. Engagement is likely to drop off, and content coverage will be minimal. A teacher must know when to move a student to new materials and activities. This is a very complex diagnostic decision that teachers must frequently make. But with proper student preparation, clear explanations, appropriate structure and sequencing, even the new material to be learned can produce a low error rate. In the conception of classroom learning proposed here, it is when teachers put students into contact with mathematics curriculum materials and activities of an easy level of difficulty that learning is hypothesized to take place.

The variable of ALT, which is measured in real time, has some roots in the work of Carroll (1963), Bloom (1976), Harnischfeger and Wiley (1976) and others. The effort to develop this variable, which focuses on student use of time and student curriculum, simultaneously, also stems from the extant literature concerned with research on teaching. In that literature

(Berliner & Rosenshine, 1977; Rosenshine & Berliner, 1978) a vector of variables which are called direct instructional variables seemed to consistently show relations with student academic achievement. The students' use of time and curriculum materials are part of that vector. And finally, the concern for the easy level of difficulty of the curriculum materials comes from our own pilot data and the instructional design literature. That literature emphasizes the importance of practice, repetition and overlearning for retention, and the utility of small steps and low error rates in learning with programmed instructional materials. With ALT a central focus of classroom research the typical process-product paradigm for research on teaching must be modified. This modification may be schematized as in Figure 1.

Insert Figure 1 about here

In this conception of research on teaching the content area the student is working on must be specified precisely, student task engagement must be judged, the level of difficulty of the task must be rated, and time must be measured. The constructed variable of ALT, then, stands between measures of teaching and measures of student achievement. A design for research using this approach requires the construction of two correlational matrices. The first is used to study how teacher behavior and classroom characteristics affect ALT. The second is used to study how ALT and achievement are related.

In this conception of how teachers influence student achievement the variable of engaged time is emphasized. Engaged time is the upper limit for ALT. And, the upper limit on measures of engaged time in classrooms, for a particular content area, is the time the teacher has allocated for

instruction in that content area. The remainder of this paper is concerned with allocated time, engaged time, and academic learning time (ALT) in different content areas. The thesis of this paper is that the marked variability in allocated time, engaged time, and in ALT, between and within classes, is the most potent explanatory variable to account for variability in student achievement, after initial aptitude has been removed as a predictor variable. A corollary of this thesis is that interactive teaching behavior (praise, questioning, use of organizers, feedback, etc.) can only be understood through their effects on ALT. In this conception of classroom learning the interactive teaching behaviors or teaching skills are not thought to be directly linked to achievement.

A Study of Instructional Time

Allocated time, engaged time, and ALT were studied during a recent school year in approximately 25 second and 25 fifth grade California classes. Teachers were trained in log-keeping procedures so that the daily time allocations for selected students could be recorded within particular content areas of reading and mathematics. In addition, a trained observer was present approximately one day a week for over 20 weeks of the school year. The observer recorded engaged time and provided data to compute estimates of ALT as well as providing data about a number of other facets of classroom life (Beginning Teacher Evaluation Study, 1976). Selections from this larger data set (Dishaw, 1977a; Dishaw, 1977b; Filby & Marliave, 1977) will be used to illustrate some of the within and between class variability in allocated time, engaged time, and ALT. Only the data on mathematics instruction will be presented in this paper.

Allocated Time

Table 1 presents allocated time in content areas of second-grade mathematics and Table 2 presents allocated time for content areas of fifth-grade mathematics. These data were obtained from teachers' logs over an average of 90 days instruction from October to May of the school year. The logs were filled out daily for six students in each of the classes. Within each grade level, the students were of comparable ability levels in reading and mathematics, both within and across classes (Cahen, 1977). The data from the six students that were studied intensively in each class will ~~be used~~ to generalize about the whole class.

Insert Tables 1 and 2 here

With the data from both second and fifth grade mathematics one can notice widespread variability in how teachers spend their time. Different philosophies of education result in different beliefs about what is important for students to learn. These beliefs, along with the teacher's likes and dislikes for teaching certain areas, result in some interesting differences in the functional curriculum of a class. For example, from Table 1 it can be seen that students in class 13 had an average of 400 minutes each to learn the concepts and operations involved in linear measurement, while students in class 5 had an average of 29 minutes each to learn these operations and concepts. In the content area of fractions and in the content area of money class 21 received very little time while class 13 received markedly more time in these areas. From Table 2 it can be seen that classrooms 14 and 18 spend dramatically more time on division than the other two fifth-grade classes. In classroom 18 fractions were

emphasized, as judged from the dramatically greater allocation of time to that content area, in contrast to the average amount of time each student of class 3, 4, and 14 received. And word problems hardly seemed to be of interest to the teachers of classes 3, 4, and 18, at least that is what can be concluded when the data from these three classes are compared with the data from class 14.

These rather significant differences in the functional classroom curriculum should, by all we know about learning, result in considerable differences in achievement. If students in these second grade classrooms were tested at the end of the year on linear measurement, you might do well to wager that students in class 13 would demonstrate better performance than students in class 5. If these fifth grade classes were part of some end-of-year statewide testing program, where fractions were tested, as it often is, one might well expect that students in classroom 18 would show superior performance when contrasted to similar students in the other fifth grade classes.

The broad-spectrum standardized achievement test in mathematics may be a social indicator, from which state or national policy can be illuminated. But as long as teachers have the freedom to choose what areas the will emphasize in their classrooms, these tests can never be used as fair measures of teacher effectiveness. It simply is not fair to teachers to evaluate their students in areas that the teacher did not cover or emphasize. On the other hand, it may not be fair to students and their parents to let teachers arbitrarily choose that which is to be taught. Some tighter control of the functional classroom curriculum may be desirable. This problem is recognized by many, and has led some curriculum developers to insist

upon stringent control of teacher behavior in order to implement the program that they would promote (e.g., Becker & Engelmann, 1978).

Another interesting aspect of allocated time is the average daily time devoted to mathematics. States and school districts often mandate a certain minimum number of minutes per day or hours per week for certain subject matters. Let us suppose, by law, that 40 minutes a day is the minimum time to be devoted to mathematics in the second grade, within a particular school district. Let us also suppose that this mathematics time begins at 11:15, after a recess, and that the time period devoted to mathematics ends at noon. The teacher, principal, and superintendent may well feel that the state minimum requirements are being met and exceeded. But careful observation will reveal otherwise. A 10-minute delay in the start of the work, called transition time in the Beginning Teacher Evaluation Study, may occur before the mathematics curriculum is really in effect. Toward the end of the allocated time students are putting workbooks, contracts, and cuisinaire rods away, getting lunches out, and lining up for the noontime dismissal. Another ten minutes may be lost. Functional time for mathematics is now 25 minutes, which is 60 percent under the legal requirement.

The data presented in Table 1 reflect this difficulty in classroom management of time. Classes 5 and 21 have, on the average, a daily allocation of mathematics totalling about 30 minutes per day, while classes 8 and 13 show, on the average, an allocation of time to mathematics of over 50 minutes per day. From other data collected as part of this study we estimate that the students in class 5 and class 21 spend an average of 42.5 minutes per day in transitions from activity to activity, while students in classes 8 and 13 spend about half that time, approximately 22 minutes per day, in

transitions. The average daily minutes per day devoted to fifth grade mathematics, as presented in Table 2, show similar variability. Teachers in classes 14 and 18 have allocated over 100 percent more total time to mathematics than did the teachers in classes 3 and 4. Other data from our full fifth grade sample reveals that the teachers with the lower rate of allocated time had higher than average class time spent in transitions and behavioral management. What this indicates is that the time allocated for academic instruction in a school day can easily slip away when a teacher cannot keep the transitional time and behavioral problems to a minimum. Any sensible manager knows that. Somehow, however, in many classes, there is a casualness about classroom management that results in considerable inefficiency.

This brief examination of selected data presenting estimates of classroom allocated time shows clearly that some teachers spend considerable more time instructing in particular content areas than other teachers, and some teachers allocate considerably more total instructional time than do other teachers. These differences, put into experimental terminology, represent clear differences in the type and in the duration of treatment. One can expect, therefore, considerable variability on the outcome measures used to assess these vastly different treatments.

One other instructional variable of interest to an instructional designer is sequence of instruction. Not only should type and duration of instruction affect learning outcomes, but the sequencing of the instruction should also affect what is learned. Do students in different classrooms accumulate their time in the same content areas in different ways? Table 3 presents data to answer this question. In this table the raw allocated and cumulative allocated time for five second grade students receiving

instruction in addition and subtraction (no regrouping) is recorded. Student 0506 received about 100 percent more time in this content area than did the other students. And he received it continuously through the 17 weeks of instruction. Student 0702 received his instruction in 10 weeks flat. No review or further instruction were noted in this content area. Student 1006 received two-thirds of her instruction in 9 weeks, but had one-third more instructional time in this content area allocated from weeks 10-17. These vastly different sequences of instructional time allocations are, from an instructional design standpoint, quite important. They are systematically uninvestigated variables in most research on teaching

Insert Table 3 about here

Engaged Time

Tables 1 and 2 also present data on the average percent of time students are engaged in mathematics instruction. These data are from observer records, and not from teacher logs. Previous work revealed that teachers can keep accurate records of allocated time, but that classroom observers were necessary to obtain accurate records of engaged time (Marliave, Filby, & Fisher, 1976). In examining these data it appears that the percent of time students are engaged is relatively high. This is an artifact of the observational system that was in use. The observation system required that transition time and other classroom phenomena be coded as separate events. Thus, the data on engagement rates are for the time spent in mathematics, after a class has settled down and before the class starts to put their work away. If engagement were coded for the entire time-block denoted by teachers as mathematics time, the engaged time rates would be considerably

lower because during transitions most of the class is not engaged. Still, variability between classes is noted for a potentially important variable. The engagement rates in these four second-grade classes vary from 61 percent to 78 percent during mathematics instruction. In the four fifth-grade classes, engagement rates vary from 60 percent to 80 percent during mathematics instruction. These ranges were much larger in the total sample of classes that were studied.

The average number of minutes per day allocated for instruction, multiplied by the engagement rate, provides liberal estimates of the number of engaged minutes per day, per student. These data are found in Table 1 and Table 2. In the second-grade mathematics data, at the lower end of the range, 20 minutes of engaged time per day is noted. At the higher end of the range 40 minutes per day is noted. For fifth-grade mathematics the range in these four classes is between 17 and 49 minutes per day of engaged time. These are dramatic differences, differences of 100% or more, in the engaged time students allot to learn their mathematics. For reasons that we do not yet fully understand, some combination of teacher behavior and students' socialization to school interact to produce classes where most of the children are attending to their work most of the time. And these same factors sometimes result in classes where less than half of the children are attending to their work during the time allocated for instruction.

In most districts we may assume that a school year is about 180 days. This figure must be reduced by absences of teachers and students, strikes, bussing difficulties, the difficulties of instruction before Christmas and Easter breaks, the testing at the beginning and end of the school year, and other factors. A reasonable estimate of the "functional" school year may

be about 150 days. Accumulating the engaged minutes per day over these 150 days gives an estimate of the engaged instructional time allotted by students to the academic curriculum during the entire school year. Tables 1 and 2 present these data for the four classes in each grade level. Between 50 and 100 hours per year of active student involvement in classroom mathematics instruction is noted in the four second-grade classes. In the four fifth-grade classes, even with more mature and supposedly more independent learners, the range is between 43 and 123 cumulative hours per school year.

As these data come to light some important questions must be asked. For example, what should be expected in the way of engaged time for 30 students and one teacher, working together throughout the school year? What are the expectations for instructional time held by parents and school board members as they make policy to educate the young of a community? Because these new estimates of classroom allocated and engaged time do not conform to the prevailing beliefs that exist among the people who manage and support education, either those beliefs must be changed, or instructional practices must be altered.

Academic Learning Time

As noted above, academic learning time is the research variable of most interest in the Beginning Teacher Evaluation Study. One component of ALT is the level of difficulty of the material that is attended to by a student. It is the belief of the investigators that learning occurs primarily with materials of an easy difficulty level. Materials that are too hard for a student do not add much to his acquisition of the concepts, skills, and operations that are required of students in a particular grade level. Materials that are easy to master promote retention. High levels

of retention are needed for demonstration of achievement gains in end of year testing programs. Tables 1 and 2 present information on the percent of time that students are working with material of an easy level of difficulty. These data are ratings made by observers in classrooms. As shown in Table 1, for second-grade mathematics, the range is between 55 percent and 67 percent. In fifth-grade mathematics the range is between 41 percent and 80 percent. Multiplying the engaged minutes per day by the percent of time students are assigned work of an easy level of difficulty provides an estimate of ALT per day. These data are also provided in Tables 1 and 2.

As noted above, the typical academic school year of 180 days may be considered to be a functional school year of 150 days. The last line in Table 1 and Table 2 presents academic learning time, in hours, for a school year of 150 days. In these four classes, at each grade level, differences of many hundreds of percent in accumulated ALT are noted. In second grade mathematics the range is from 30 hours per school year to 58 hours per school year. In fifth-grade mathematics the range is from 18 hours per school year to 53 hours per school year. In the total sample studied the range of ALT is larger. It should also be noted that all the elementary school teachers in this sample were volunteers. These data, if they could be obtained from a non-volunteer sample, would most likely show even more between class variability.

If academic learning time is one key to acquiring the knowledge and skill required to master the curriculum of a particular grade level, for a particular content area, one can see that the school year does not contain as much ALT as might be desired. If our concerns about instruction are correct, there are many, many classes where there is not sufficient time

for students to master the curriculum which has been chosen for them.

Relations between the Three Time Variables

One way to think about the relations between allocated time, engaged time, and academic learning time is to examine the bar graph presented in Figure 2. The three time variables were measured in the content area of place value in second grade mathematics. These data from five students present an interesting problem, whose implications will be understood better in future studies. If we rank order the students in terms of allocated time, the students would order one way; if we rank ordered by engaged time, they would rank order a second way; and if we rank ordered by ALT they would order a third way. In particular, student three received the lowest allocation of time in place value, displayed the fourth highest level of engaged time, and showed the third highest level of ALT. We think these changes in magnitude of the three variables have important implications for classroom learning. But, we do not yet fully understand them.

Insert Figure 2 about here

Summary

Descriptive data on allocated time, engaged time, and academic learning time have been presented. The data from four second-grade and four fifth-grade classes, chosen to reflect differences in the variables of interest, were examined. If the type of treatment and the duration of treatment and the sequence of treatment are crucial variables in the determination of what is learned and how much is learned, then the between class differences in the weekly and total allocated time in content areas, and in total allocated time per day or per school year, become important operationally

defined behavioral indicators of the instructional treatment. If learning is likely to occur only when students attend to the instruction offered them, then between class differences in engaged time become an important operationally defined behavioral indicator of the effective stimulus situation, as opposed to the nominal stimulus situation. And finally, if learning primarily takes place when students are engaged with materials and activities that are of an easy level of difficulty for that particular student, then ALT becomes an important operationally defined behavioral indicator of student learning. The construct of ALT has an intriguing virtue. One does not need to wait until the end of the school year to decide if learning has taken place. One can study learning as it happens, if the construct of ALT is accepted as it has been defined. In the conception of instruction that has guided the research that has been conducted, ALT and learning are synonymous.

The common-sense logic of the above statements is appealing. Empirical evidence, at this writing, is very encouraging. The ALT variables, in regression analyses, are accounting for about 10 percent of the variance in mathematics achievement in the various content areas, after the effects of pretests have been removed. This is quite a lot. Both logic and empirical data urge us to examine seriously the role of allocated time, engaged time, and ALT in promoting achievement. Such concerns can lead teachers and supervisors of teachers to examine classroom processes in ways that logically relate to student achievement. Without turning classes into authoritarian factories of learning, many teachers can improve their effectiveness by attending to these variables and reorganizing classroom practice to maximize teaching time and learning time--resources over which they have considerable personal control.

[1] The ideas and data presented in this paper emerged from work performed while conducting the Beginning Teacher Evaluation Study. That study was funded by the National Institute of Education and administered by the California Commission for Teacher Preparation and Licensing. The research was conducted by the Far West Laboratory for Educational Research and Development. The study has been a joint effort by David C. Berliner, Leonard S. Cahen, Nikola N. Filby, Charles W. Fisher, Richard N. Marliave, and Jeffry E. Moore.

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Teacher Behavior and Classroom Characteristics	→	Student Engaged Time with Appropriate Curriculum Content (ALT)	→	Student Achievement in that Curriculum Content Area

Figure 1. Simple Flow of Events that Influence Achievement in a Particular Curriculum Content Area

Place Value

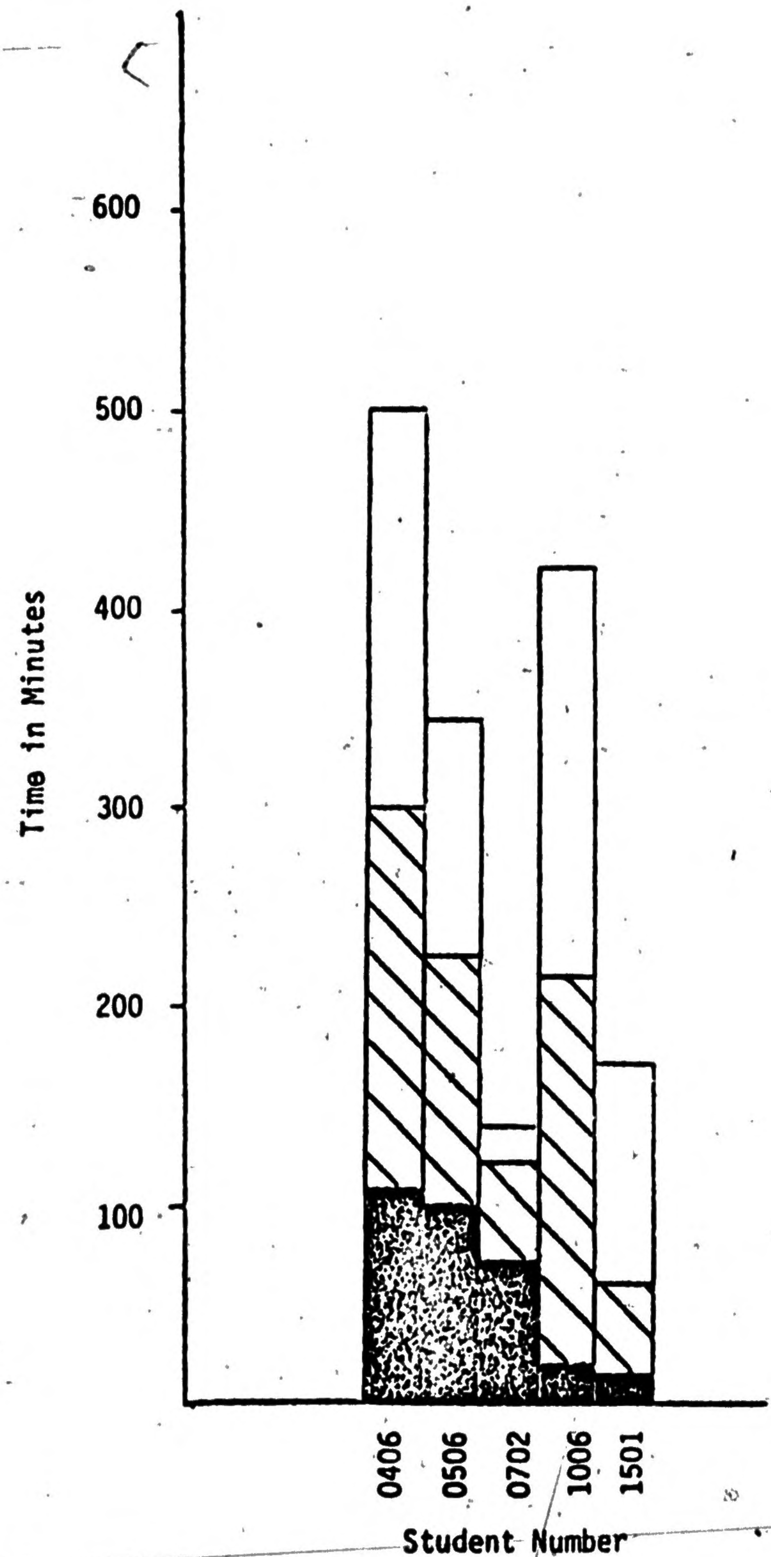

Figure 2 Allocated time, engaged time, and engaged time on tasks with low error rate for 5 students.

Note: Times are in minutes accumulater over 17 weeks of instruction.

Source: Cahen and Fisher, 1978

TABLE 1*

Pupil time (in minutes) in content areas of mathematics and other variables for four second grade classes

	LOG CONTENT AREAS AND OTHER VARIABLES	CLASSES 5	21	8	13
Computation	Addition and subtraction, no regrouping, short form.	835	420	1839	540
	Addition and subtraction, no regrouping, instructional algorythym.	172	177	131	596
	Addition and subtraction, with regrouping, short form.	0	357	246	736
	Addition and subtraction, with regrouping, instructional algorythym.	43	464	138	723
	Speed tests.	232	31	71	100
	Other computation.	0	3	68	15
Concepts/ Applications	Computational transfer.	453	185	580	130
	Place value/numerals.	416	352	684	692
	Word problems.	109	226	416	132
	Money.	98	9	228	315
	Linear measurement.	29	130	107	400
	Fractions.	0	21	63	399
	Developmental activities	0	76	111	40
	Other concepts or applications.	145	237	54	309
	Total time in minutes.	2530	2687	4736	5127
	Number of days data collected.	93	83	94	96
	Average time per day, in minutes.	27	32	50	53
	Percent of time students engaged.	71	62	61	78
	Engaged minutes per day.	19	20	31	41
	Percent of time students are in material of an easy difficulty level.	67	59	65	55
	Academic learning time per day in minutes.	1[illegible]	12	20	23
	Engaged hours per 150 days school year.	48	50	78	103
	Academic learning time per 150 day school year, in hours.	33	30	50	58

*Sources: Dishaw, 1977(a); Dishaw, 1977 (b); Filby and Marliave, 1977.

TABLE 2*

Pupil time (in minutes) in content areas of mathematics and other variables for four fifth grade classes

	LOG CONTENT AREAS AND OTHER VARIABLES	CLASSES 3	4	14	18
COMPUTATION	Addition.	33	234	95	26
	Subtraction.	77	205	248	4
	Multiplication: Basic facts.	40	79	89	142
	Multiplication: Speed tests.	34	51	8	24
	Multiplication: Algorythym.	341	910	720	343
	Division.	243	19	1548	2223
	Fractions.	54	370	495	2016
	Other.	0	82	213	0
CONCEPTS/ APPLICATION	Computational transfer.	49	24	160	147
	Numerals/place value (whole number).	0	53	29	0
	Word problems.	58	3	322	15
	Geometry: Perimeter.	0	53	73	0
	Geometry: Area.	0	103	49	0
	Geometry: Number pairs.	90	40	0	0
	Geometry: Lines or figures.	418	126	70	280
	Other.	174	128	1411	68
	Total time in minutes.	1611	2480	5530	5288
	Number of days data collected.	73	89	91	93
	Average time per day, in minutes.	23	28	61	57
	Percent of time students engaged.	74	80	80	66
	Engaged minutes per day.	17	22	49	38
	Percent of time students are in material of an easy difficulty level.	41	80	42	28
	Academic learning time per day in minutes.	7	18	21	11
	Engaged hours per 150 day school year.	43	55	123	95
	Academic learning time per 150 day school year, in hours.	18	45	53	28

*Sources: Dishaw, 1977(a); Dishaw, 1977(b); Filby and Marliave, 1977.

Table 3

Time allocated to addition and subtraction (no regrouping) for 5 students over 17 weeks of instruction

Week	Student 0506 Raw	Student 0506 Cum	Student 0702 Raw	Student 0702 Cum	Student 1006 Raw	Student 1006 Cum	Student 1501 Raw	Student 1501 Cum	Student 0405 Raw	Student 0405 Cum
1	30	30	40	40	45	45	60	60	35	35
2	62	92	95	135	20	65	30	90	20	55
3	105	197	0	135	10	75	20	110	80	135
4	105	302	0	135	0	75	50	160	35	170
5	20	322	50	185	20	95	20	180	40	210
6	0	322	20	205	30	125	30	210	0	210
7	5	327	90	295	50	175	30	240	0	210
8	15	342	45	340	40	215	30	270	0	210
9	50	392	10	350	20	235	20	290	10	220
10	30	422	30	380	55	290	10	300	45	255
11	20	442	0	380	25	315	0	300	20	285
12	80	522	0	380	0	315	30	330	15	300
13	38	560	0	380	0	315	0	330	0	300
14	0	560	0	380	0	315	0	330	0	300
15	20	580	0	380	10	325	0	330	5	305
16	30	610	0	380	35	360	0	330	0	305
17	55	665	0	380	4	364	0	330	10	315

Entries are in minutes.
Source: Cahen and Fisher, 1978.